Australian Dental Journal
The official journal of the Australian Dental Association

Australian Dental Journal 2024; 69: 82–92

doi: 10.1111/adj.12987

Self-reported oral health status, edentulism and all-cause mortality risk in 12 809 Australian older adults: a prospective cohort study

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ABSTRACT

Objective: To investigate the association between oral health status and all-cause mortality in older adults using prospective cohort study design.
Setting and participants: In total, 12 809 adults aged ≥70 years (54.3% females) were participants of the ASPREE Longitudinal Study of Older Persons (ALSOP).
Methods: Participants self-reported the presence of natural teeth and oral health status. The association of self-reported oral health, edentulism and the integrative measure of the two with all-cause mortality were explored using the Cox-regression models adjusted for age, gender, socio-economic status, health-related behaviours, weight status, aspirin and polypharmacy. Hazard ratios (HRs) and 95% confidence intervals (CIs) were reported.
Results: In total, 22.2% of participants reported edentulism and 13.8% had fair/poor oral health. After adjustment for confounders, risk of all-cause mortality was higher among those with edentulism (vs. no edentulism) HR (95% CI) 1.43 (1.18, 1.73); and those with edentulism and reporting poor/fair oral health HR (95% CI) 1.69 (1.02, 2.82), or with no edentulism but reporting poor/fair oral health HR (95% CI) 1.46 (1.19–1.80) vs. no edentulism and reporting good/very good/excellent oral health. No association was observed between self-reported oral health alone and all-cause mortality.
Conclusions: The risk of all-cause mortality was 69% higher among older adults reporting both edentulism and poor/fair oral health compared with those with teeth and more favourable self-reported oral health. © 2023 Australian Dental Association.

Keywords: Cohort study, edentulism, mortality, oral health, tooth loss.

Abbreviations and acronyms: ALSOP = ASPREE Longitudinal Study of Older Persons; ASGS = Australian Statistical Geography Standard; ASPREE = ASPirin in Reducing Events in the Elderly; ASPREE-XT = Aspirin in Reducing Events-eXTension; BMI = body mass index; CI = confidence interval; HR = hazard ratio; IQR = interquartile range; IRSAD = Index of Relative Socio-economic Advantage and Disadvantage; SEIFA = Socio-Economic Indexes For Areas; US = United States.

(Accepted for publication 4 October 2023.)

CLINICAL RELEVANCE

- Self-reported edentulism was associated with a 43% higher risk of all-cause mortality.
- All-cause mortality risk was 69% higher among older adults who reported both edentulism and having fair/poor oral health compared to those who reported having some natural teeth and good/very good/excellent oral health.
- Maintaining good oral health might reduce the risk of all-cause mortality.
- As oral health is an integral part of general health, and dental diseases accumulate over a person's lifetime, it might be essential that oral health care programs be integrated into general health programs to help improve oral health in people of all ages, including older adults.

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INTRODUCTION

Oral diseases, including dental caries and periodontitis, are major global health challenges and priorities.[1] Although most oral diseases are preventable or treatable in their early stages, it was estimated that in 2017 approximately 3.5 billion people were affected by oral diseases worldwide.[2] The most prevalent oral disease was caries of permanent teeth, affecting about 2.3 billion people, followed by periodontitis.[3] In 2019, severe periodontitis affected approximately 1.1 billion people globally with a large proportion of those who were edentulous (loss of all natural teeth) or experiencing severe tooth loss.[3] The economic burden of dental diseases is substantial, totalling about US$544 billion worldwide.[4,5] Approximately two-thirds of this amount is attributable to direct costs of oral disease treatment, while the remaining is attributable to loss of production, wages, reduced school hours and transportation costs.[4,5]

The global population is ageing, and it was estimated that by the year 2050 older adult population (65 years and older) will double from 703 million people in 2019 to 1.5 billion people.[6] Older adults often experience poorer oral health compared to the rest of the population.[7] This is potentially due to a few factors. Firstly, greater perceived barriers to accessing dental services, including lack of finances, transportation or assistance navigating dental services[8]; physical or cognitive impairment[9] or their perception that they do not need treatment despite the gap between perceived treatment needs and actual state of oral health.[10] Secondly, the prevalence of chronic diseases is higher in older adults due to the cumulative effects of life course risk factors such as tobacco smoking, energy-dense/low nutrient diet, alcohol consumption, lower physical activity, stress and inequalities in social determinants.[11] Thirdly, some medications treating chronic diseases can induce xerostomia, a risk factor for oral diseases.[12] Fourthly, consequences of natural ageing, such as muscle wasting (sarcopenia), reduced muscle strength and inadvertent tooth movement lead to wear and tear in the mouth contributing towards reduced masticatory functional capacity, compromised oro-facial aesthetics and poor quality of life.[9] Fifthly, frailty can have significant implications for oral health in older adults, as people with a lower number of teeth, poorer oral functions, use of removable dentures, accumulation of oral health problems and xerostomia were more likely to be frail.[13] Lastly, older adults belong to pre-fluoride generation, which might have contributed to poorer oral health in older adults.[14]

Tooth loss has been previously linked to an increased risk of all-cause mortality in older adults.[15–17] Evidence is scarce on the effect of self-reported oral health on the risk of all-cause mortality in this population group. Self-reported oral health provides valuable insights into a person's perception of their own oral well-being. An overall good agreement between self-reported and clinical number of teeth in older adults has recently been reported by the Norwegian researchers,[18] while self-rated oral health has also been reported as a valid measure of oral health status in people living in rural Australia.[19] Other studies have also reported that self-reported oral health measures might be valid and reliable for assessing oral health status.[20,21]

Researching self-reported oral health in older adults is important, as it is associated with unfavourable clinical oral health and unmet dental treatment needs.[22] Knowledge of the associations between edentulism and self-reported oral health with all-cause mortality in older adults will assist policymakers and clinicians when making oral health policies affecting people of all ages. Therefore, the objective of this study was to determine the association of edentulism, self-reported oral health and an integrative measure of these two, with the risk of all-cause mortality in adults aged 70 years and over.

METHODS

Study design and participants

This study is a longitudinal cohort analysis employing data from the ASPREE (ASPirin in Reducing Events in the Elderly) trial,[23] the ASPREE Longitudinal Study of Older Persons (ALSOP) sub study, and the ASPirin in Reducing Events-eXTension cohort study (ASPREE-XT).[24] This study complied with the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) protocol.

The ASPREE study was carried out with 16 703 participants aged 70 years or older in Australia and 2411 participants aged 65 years or older in the USA. It was a double-blind, placebo-controlled trial designed to determine whether daily low-dose aspirin (100 mg) could extend disability-free survival in community-dwelling older adults. ASPREE exclusion criteria included the history of cardiovascular disease, dementia or presence of physical disability, resulting in enrolment of a relatively healthy, independent-living cohort at baseline. The ASPREE study design, participant characteristics and primary results have been previously published.[25] ASPREE participants were recruited between March 2010 and December 2014, and the intervention phase ceased in 2017 (a median trial follow-up period of 4.7 years).[25] After this, participants were invited to continue observational follow-up into the ASPREE-eXTension

(ASPREE-XT) study. The ASPREE-XT study is an ongoing, follow-up observational study set to explore the long-lasting effects of low-dose aspirin on diseases, such as cancer. It also investigates factors contributing to the maintenance of physical and cognitive health in older adults.[24] For this study on the association of self-reported oral health status and edentulism with all-cause mortality, the outcome is determined after a median follow-up period of 6.4 years.

ALSOP is a survey-based longitudinal study of general health, behavioural and socioeconomic factors that might be related to health and well-being in older age.[23] ALSOP questionnaires were administered only to Australian ASPREE participants. Details of the ALSOP study methods and cohort have been published previously, with 90% of the Australian ASPREE cohort returning the first ALSOP Baseline Medical questionnaire from which this study draws data.[23]

Exposures – self-reported edentulism and oral health

Self-reported oral health status and edentulism were assessed using the baseline ALSOP medical questionnaire from responses to the question "How would you rate your oral health?". Available response options were "Excellent", "Very good", "Good", "Fair", or "Poor". Edentulism was defined as the loss of all natural teeth (full edentulism); and it was assessed by the question: "Do you have any of your own natural teeth?", and participants could respond with "Yes" or "No". For analytical purposes, the self-reported oral health variable was dichotomised as "Good/Very Good/Excellent" and "Fair/Poor".

The integrative measure of edentulism and self-reported health considers both the oral health measures. Study participants were grouped into the following four categories: (1) those reporting no edentulism (i.e., having some natural teeth left) and Good/Very Good/Excellent oral health; (2) participants reporting no edentulism and Poor/Fair oral health; (3) people reporting edentulism and Poor/Fair oral health; and (4) those reporting edentulism and Good/Very Good/Excellent oral health.

Outcome variable – all-cause mortality

All-cause mortality was drawn from the ASPREE trial, for which cause of death was an adjudicated endpoint.[23] Notification of death was often provided by the treating primary care clinicians or the participant's next of kin, and clinical records were routinely reviewed. Deaths were confirmed by two independent sources (family, primary care physician or public death notice). Linkage to the National Death Index was undertaken to ascertain the vital status of participants who had withdrawn from the study or were lost to follow-up.

Covariates

Covariates were chosen based on previous evidence featuring variables that in previous studies had been associated with both oral health and all-cause mortality.[26] Variables included in these analyses were collected at baseline: self-reported age, gender (males, females), education (12 years or less, more than 12 years), living situation (living alone, living with others), smoking status (former, current, never), alcohol consumption (former, current, never), aspirin use (yes, no) and polypharmacy (yes, no; defined as the concurrent use of five or more medications).[23] Body mass index (BMI) was also included, and it was calculated from the objectively measured height and weight (weight divided by squared height and expressed in kg/m^2).

Socio-economic indexes for areas (SEIFA), and remoteness (lives within major cities, lives outside major cities) were also considered. SEIFA was derived from the Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) by the Australian population census of 2011.[27] The participants were characterised into quintiles of IRSAD by postal area, where a lower quintile indicated relatively less advantage compared to a higher quintile relatively more advantage. Remoteness was determined based on the linkage of residential postcode to the Australian Statistical Geography Standard (ASGS) Remoteness structure.[28]

Data analysis

Baseline characteristics of study participants were stratified by exposure, i.e., variable that integrates edentulism and self-reported oral health and presented as counts and percentages if categorical, and as mean and standard deviation if continuous. The associations of self-reported oral health, edentulism and a variable integrating these two oral health variables, with all-cause mortality were explored using the Cox-proportional hazard regression analyses. These analyses are used to examine a times-to-event outcome and provide efficiency and flexibility in adjusting for multiple covariates. Several models were explored. Model 1 was crude (unadjusted). Model 2 was adjusted for age and gender. Model 3 was model 2 with additional adjustment for formal level of education, SEIFA, remoteness and living status. Model 4 was model 3 with additional adjustments for smoking status, alcohol consumption, BMI, aspirin and polypharmacy. The last model included aspirin to ensure any relationship between self-reported oral health and all-cause mortality is not confounded by an aspirin effect, as

the results of the ASPREE trial indicate that the aspirin was associated with increased risk of mortality, particularly cancer-related mortality,[25] while aspirin has also been linked with oral health.[29] To address the issue of potential reverse causality, a sensitivity analysis was performed excluding participants who died within two years from the ASPREE baseline data collection (n = 68). The proportional hazards assumption was tested and assessed graphically based on Schoenfeld residuals. These were completed for all models and concluded that the proportional hazards assumption was not violated.

Spearman correlations were performed to check correlations among covariates. All correlation coefficients were low (Spearman rho < 0.2), indicating an absence of multicolinearity. Gender, education status and area-level deprivation (SEIFA) were tested for interaction and did not modify the association of edentulism and self-reported oral health with all-cause mortality (for each interaction analysis $P > 0.05$), so the analyses were performed on the total study sample. Results were considered statistically significant if the relevant P-value was <0.05. All the analyses were carried outusing Stata 16 (StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC).

RESULTS

A total of 12 809 participants who had complete data on all variables of interest were included in this study (Fig. 1). Compared to participants included in this study, those with missing data (n = 2083) were more likely to be older, female, with a lower level of formal education, current smokers, never or former alcohol consumers, and with a greater BMI. A greater proportion of participants who died was also in the group of participants missing data (Table S1).

The mean age of participants was 75 years and just over half were females (54.3%) (Table 1). Compared to their counterparts, older adults reporting no natural teeth remaining (edentulism) and poor/fair oral health were more likely to be female, live outside major cities, be current smokers but formerly or never

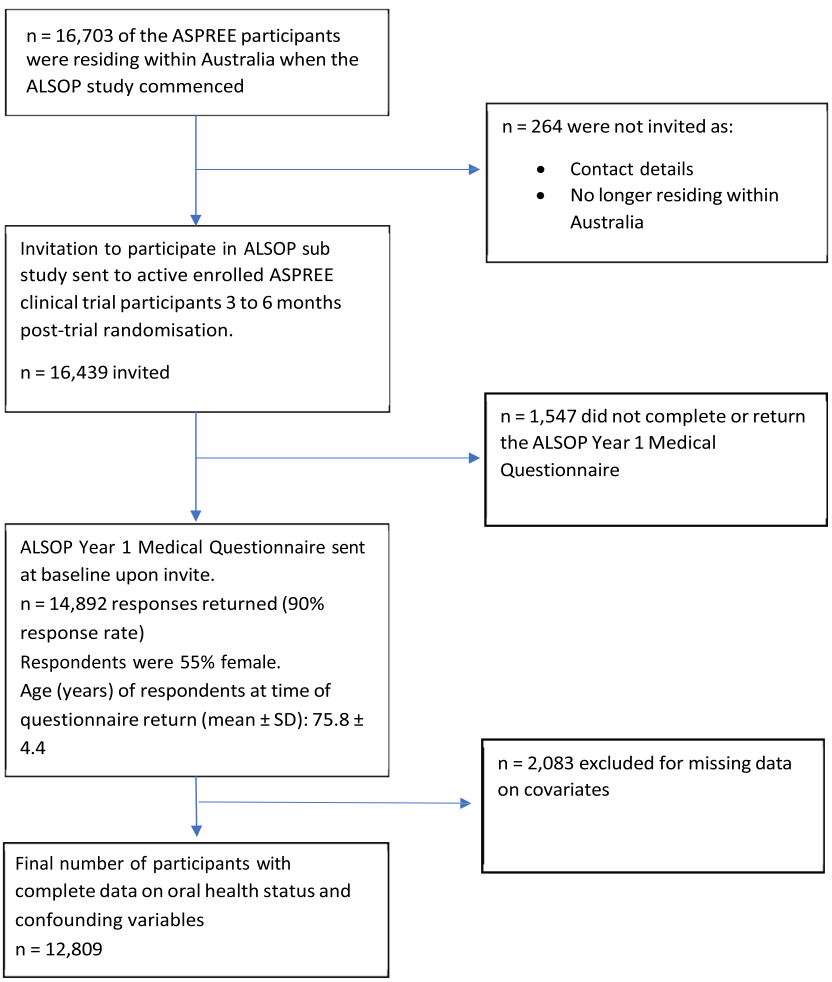

Fig. 1 Participant flow chart.

Table 1. Baseline characteristics of 12 809 males and females aged 70 years and over stratified by edentulism and self-reported oral health

Baseline characteristics	Total participants	Integrative measure of edentulism and self-reported oral health				*P*-value
		Edentulism and poor/fair oral health	No edentulism (having some natural teeth) and poor/fair oral health	Edentulism and good/very good/ excellent oral health	No edentulism (having some natural teeth) and good/very good/ excellent	
	N = 12 809	n = 223	n = 2543	n = 1502	n = 8541	
Age (years), mean ± SD	75.2 ± 4.3	76.2 ± 4.8	76.2 ± 4.7	74.9 ± 4.0	74.9 ± 4.1	<0.001
Gender, n (%)						
Female	6954 (54.3)	138 (61.9)	1516 (59.6)	719 (47.9)	4581 (53.5)	<0.001
Male	5855 (45.7)	85 (38.1)	1027 (40.4)	783 (52.1)	3960 (46.5)	
Education, n (%)						
<12 years	6184 (48.3)	146 (65.5)	1730 (68.0)	662 (44.1)	3646 (42.7)	<0.001
≥12 years	6625 (51.7)	77 (34.5)	813 (32.0)	840 (55.9)	4895 (57.3)	
SEIFA quintiles, n (%)						
1 – Least advantaged	2049 (16.0)	49 (22.0)	606 (23.8)	241 (16.1)	1153 (13.5)	<0.001
2	2168 (16.9)	50 (22.4)	525 (20.6)	254 (16.9)	1339 (15.7)	
3	2380 (18.6)	34 (15.2)	517 (20.4)	300 (20.0)	1529 (17.8)	
4	2454 (19.2)	43 (19.3)	472 (18.6)	260 (17.3)	1679 (19.7)	
5 – Most advantaged	3758 (29.3)	47 (21.1)	423 (16.6)	447 (29.7)	2841 (33.3)	
Remoteness, n (%)						
Live in major cities	6806 (53.1)	106 (47.5)	1041 (40.9)	815 (54.3)	4844 (56.7)	<0.001
Live outside major cities	6003 (46.9)	117 (52.5)	1502 (59.1)	687 (45.7)	3697 (43.3)	
Living status, n (%)						
Alone	3810 (29.7)	97 (43.1)	930 (36.6)	407 (27.1)	2376 (27.8)	<0.001
Not Alone	8999 (70.3)	127 (56.9)	1613 (63.4)	1095 (72.9)	6164 (72.2)	
Smoking status, n (%)						
Current	357 (2.8)	11 (4.9)	115 (4.5)	52 (3.5)	179 (2.1)	<0.001
Former	5276 (41.2)	104 (46.6)	1107 (43.5)	693 (46.1)	3372 (39.5)	
Never	7176 (56.0)	108 (48.5)	1321 (52.0)	757 (50.4)	4990 (58.4)	
Alcohol consumption, n (%)						
Current	10 218 (79.8)	152 (68.2)	1829 (71.9)	1232 (82.0)	7005 (82.0)	<0.001
Former	595 (4.6)	14 (6.3)	145 (5.7)	82 (5.5)	354 (4.2)	
Never	1996 (15.6)	57 (25.5)	569 (22.4)	188 (12.5)	1182 (13.8)	
BMI (kg/m^2), mean (SD)	27.9 ± 4.5	28.1 ± 4.9	28.6 ± 4.7	28.1 ± 4.6	27.6 ± 4.4	0.004
Polypharmacy, n (%)						
Yes	3195 (24.9)	84 (37.7)	770 (30.3)	385 (25.6)	1956 (22.9)	<0.001
No	9614 (75.1)	139 (62.3)	1773 (69.7)	1117 (74.4)	6585 (77.1)	
Aspirin, n (%)						
Yes	6380 (49.8)	108 (48.4)	1294 (50.9)	761 (50.7)	4217 (49.4)	0.502
No	6429 (50.2)	115 (51.6)	1249 (49.1)	741 (49.3)	4324 (50.6)	

consuming alcohol, and concurrently use 5 or more medications. Similarly, compared with the rest of the participants, those with or without edentulism but reporting poor/fair oral health were more likely to live in the least socio-economically advantaged neighbourhoods, and live alone (Table 1).

About a quarter of the participants (22.2%) reported to be edentulous, and 13.8% reported their oral health as fair/poor; however, the majority of the study participants (65.9%) reported both no edentulism and having good/very good/excellent oral health (Table S2). A greater proportion of deaths was observed among older adults who were edentulous, reporting fair/poor oral health and those reporting both edentulism and fair/poor oral health compared to their counterparts reporting more favourable oral health status (Fig. 2).

After 6.4 median years of follow-up (IQR: 5.5–7.8 years), 535 (4.1%) deaths were recorded. In the models on edentulism and those featuring the integrative measure of edentulism and self-reported oral health, adjustment for age, gender, socio-economic status, behavioural characteristics, BMI, aspirin and polypharmacy, reduced the size of the effect of oral health status variables on all-cause mortality. In a fully adjusted model (Model 4), and compared to older adults who reported having some natural teeth (no edentulism), the risk of all-cause mortality was higher among those with edentulism (HR [95% CI]: 1.43 [1.18, 1.73]; P<0.001; Fig. 3; Table S3). No association was observed between self-reported oral health alone and risk of all-cause mortality (Fig. 3b; Table S3). However, when considering both edentulism and self-reported oral health, and compared to

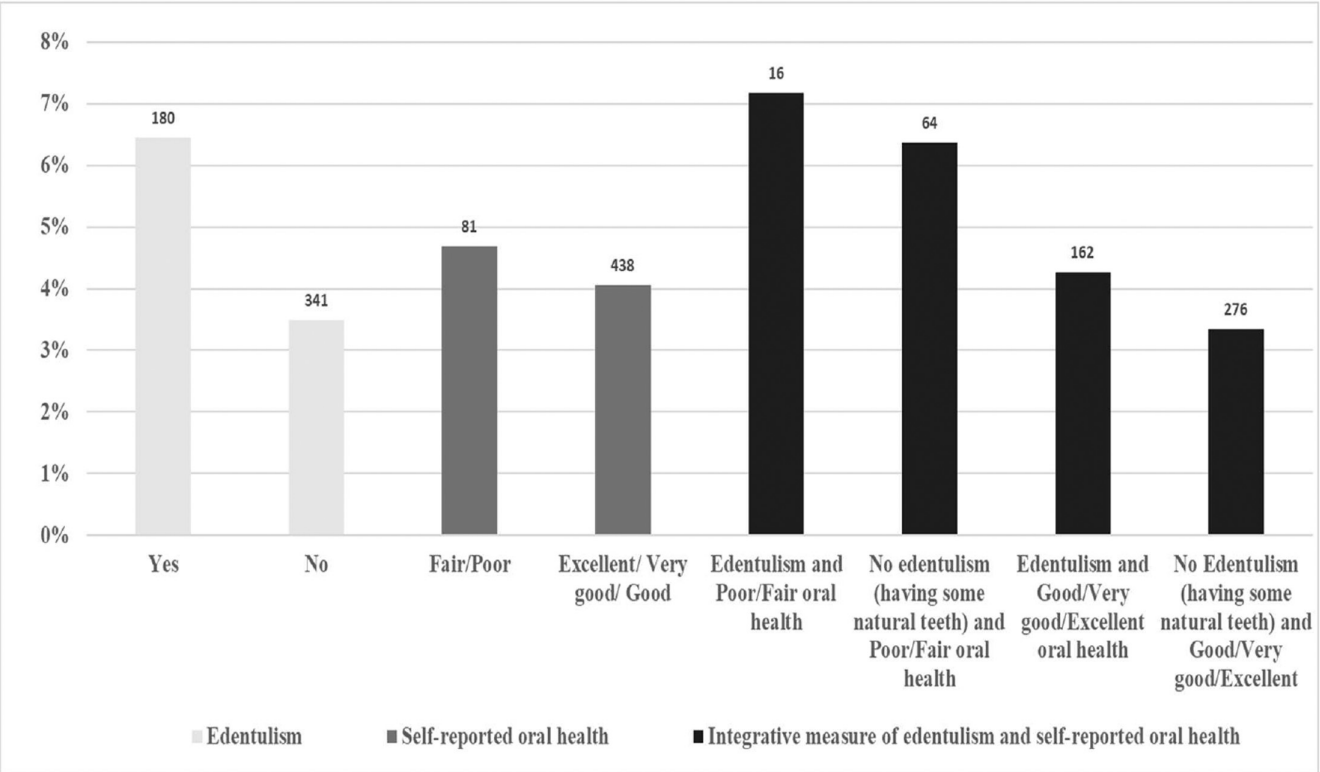

Fig. 2 Proportion and number of deaths across categories of oral health status in 12 809 adults aged 70 years and over.

older adults who had some natural teeth and reported good/very good/excellent oral health, those who reported being edentulous and poor/fair oral health had 69% higher risk of all-cause mortality (HR [95% CI]: 1.69 [1.02, 2.82]; $P = 0.043$; Fig. 3c; Table S3). Similarly, the risk of all-cause mortality was also higher among older adults who reported no edentulism but poor/fair oral health compared to their counterparts who had some natural teeth and reported good, very good or excellent oral health (HR [95%CI]: 1.46 [1.19, 1.80]; $P < 0.001$; Fig. 3c; Table S3). A higher risk of all-cause mortality was also observed for older adults who reported being edentulous and having good/very good/excellent oral health, however, the corresponding result was not statistically significant (HR [95%CI]: 1.21 [0.92, 1.59]; Fig. 3c; Table S3). Sensitivity analyses with participants excluded if they died within the first two years from the start of the study produced similar results (Table S4).

DISCUSSION

In the study of over 12 000 older adults, we explored the association of reported edentulism and oral health with the risk of all-cause mortality and observed a 43% greater risk of all-cause mortality among older adults who reported edentulism compared to those who reported having some natural teeth. However, the risk of all-cause mortality was 69% higher among older adults who reported both edentulism and having fair/poor oral health compared to those who reported having some natural teeth and good/very good/excellent oral health. These results are important, as they indicate that maintaining good oral health might reduce the risk of all-cause mortality. Hence, oral health care should be an integral component of primary health care. Furthermore, as the influences of dental diseases accumulate over a person's life, we argue that oral health care should be an integral component of primary health care for everybody, not just for older people.

We observed that edentulism was associated with a 43% greater risk of all-cause mortality in older adults, which is consistent with the results of a recent meta-analysis of 15 prospective cohort studies with a total of 306 807 adult participants where it was reported that the risk of all-cause mortality was 57% higher among individuals with edentulism (32 teeth loss) compared to those without edentulism.[26] Only four studies in this review focused on the older adult population.[16,30–32] In the Finnish population-based prospective cohort study (The Evergreen Project), in which 85-year-old males and females were followed up for five years, the lower number of remaining teeth was associated with a greater mortality risk.[30] Similar was observed in the retrospective cohort study from Taiwan where data were analysed for 55 651 adults

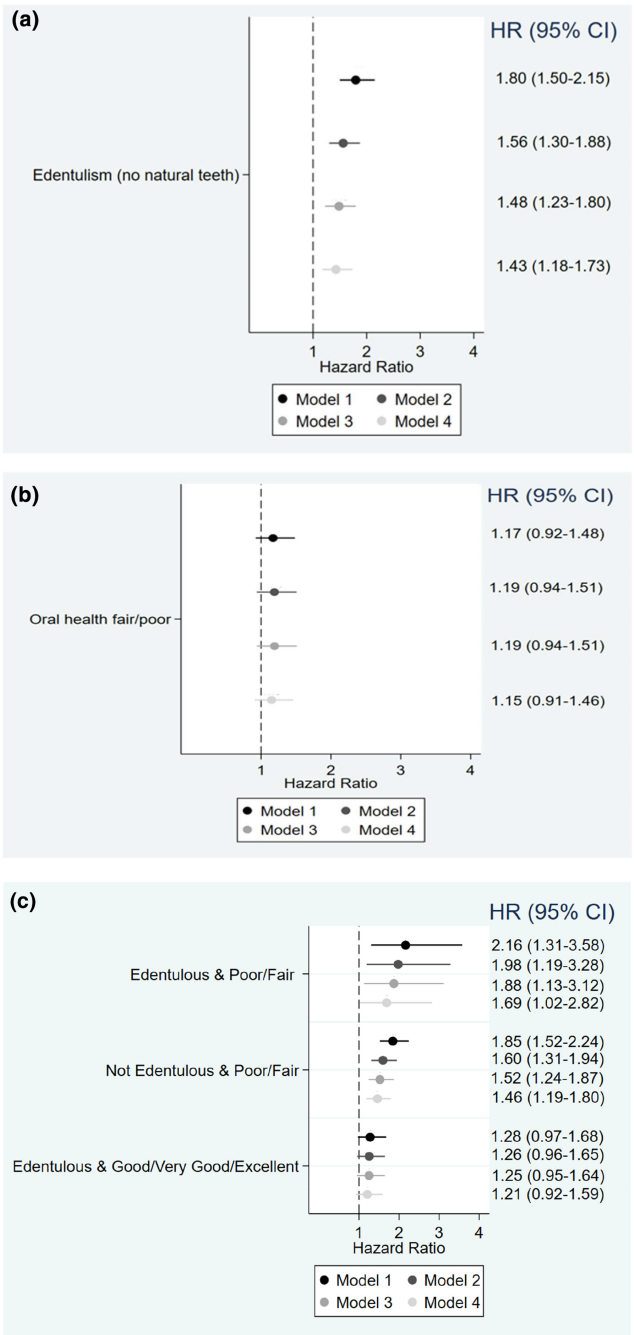

Fig. 3 (a) The association between edentulism and all-cause mortality in 12 809 older adults: the results of Cox-proportional hazards regression. The reference is participants who are not edentulous (have natural teeth remaining). Model 1: crude (unadjusted); Model 2: adjusted for age and gender Model 3: Model 2+, formal level of education, SEIFA, remoteness and living status; Model 4: Model 3+ smoking status, alcohol consumption, body mass index, aspirin and polypharmacy. HR, hazard ratio; 95%CI, 95% Confidence interval. (b) The association between self-reported oral health and risk of all-cause mortality in 12 809 adults aged 70 years and over: the results Cox-proportional hazards regression. The reference is participants who self-reported excellent/very good/good oral health status. Model 1: crude (unadjusted); Model 2: adjusted for age and gender Model 3: Model 2+, formal level of education, SEIFA, remoteness and living status; Model 4: Model 3+ smoking status, alcohol consumption, body mass index, aspirin and polypharmacy. HR, hazard ratio; 95%CI, 95%CI. (c) The association of the integrative measure of edentulism (loss of all natural teeth) and self-reported oral health, with the risk of all-cause mortality in 12 809 adults aged 70 years and over. The reference is participants who are not edentulous (have teeth remaining) and self-reported excellent/very good/good oral health status. Model 1: crude (unadjusted); Model 2: adjusted for age and gender Model 3: Model 2+, formal level of education, SEIFA, remoteness and living status; Model 4: Model 3+ smoking status, alcohol consumption, body mass index, aspirin and polypharmacy. HR, hazard ratio; 95%CI, 95% Confidence interval.

aged 65 years and over.[16] The results of the study indicate that the lower number of teeth was associated with a greater risk of all-cause mortality with a 36% higher risk of all-cause mortality observed for older adults who were edentulous compared to their counterparts with 20 or more teeth.[16] In the Swedish study, 1803 adults from four birth cohorts were examined at 70 years of age, and it was observed that each remaining tooth at age 70 decreased the 7-year mortality risk by 4%.[31] Similarly, the results of the US-based Leisure World Cohort Study of 5611 older adults followed-up for a median of 9 years indicate that edentulous individuals had a 30% higher risk of all-cause mortality compared to dentate older adults with 20 or more teeth.[32]

Results of more recent studies, such as the Brazilian Health, Well-being and Ageing Study, were consistent with previous evidence. Namely, researchers followed up 1687 participants (aged 60 to 102 years) for 11 years and observed that edentulous older adults had a 34% higher risk of all-cause mortality compared to their dentate counterparts.[17] Similarly, the results of a recent study that used cohort data from the UK-based British Regional Heart Study (2147 participants, 71–92 years with 9-year follow-up) and The US-based Health, Ageing and Body Composition Study (3075 participants, 71–80 years with 15-year follow-up) indicate that in both cohorts edentulism was associated with an increased risk of all-cause mortality.[33] Our study adds to the available evidence by reporting a 43% greater risk of all-cause mortality among edentulous adults aged 70 years and older compared to their counterparts with some remaining teeth. In addition, we report novel evidence on a 69% greater risk of all-cause mortality among older adults who both reported edentulism and fair/poor oral health compared to those with some teeth and more favourable reported oral health status.

We observed no association between self-reported oral health and risk of all-cause mortality in adults aged 70 years and over. This is consistent with the findings of the above-mentioned British Regional Heart Study and the Health, Ageing and Body Composition Study, where no association between self-rated oral health and all-cause mortality was observed.[33] However, the results of our study were in

contrast with those of the Australian 45 and Up Study in which 172 630 participants aged 45 to 75 years were followed up for a median of 3.9 years; and the risk of all-cause mortality increased with worsening self-reported oral health.[34] We also observed a dose-response relationship, with the highest risk of all-cause mortality observed for older adults reporting poor oral health (1.32 [0.67–2.58]); however, the results were not statistically significant (Table S5). The difference in the results might lie in the difference of the population under study, as we exclusively focused on the self-rated oral health of adults aged 70 years and over, while the 45 and Up Study also included middle-aged adults.

Across regression models, we observed a substantial attenuation of the size of the effect of oral health variables on all-cause mortality after adjustment for putative confounders. This indicates that part of the association of edentulism and the integrative measure of edentulism and self-reported oral health with the risk of all-cause mortality could be explained by socio-economic factors and health-related behaviours; a finding consistent with previous studies in older adults.[17]

Oral health problems in older age have a substantial impact on oral and general health-related quality of life and well-being of older adults.[35] Oral health problems can also cause malnutrition, as poor-oral health affects mastication and swallowing, which can lead to deficiency in energy and nutrient intake,[36] and malnutrition increases the risk of mortality in older adults.[37]

Study limitations and strengths

One of the limitations of the study was that study participants were apparently healthy as, based on the clinical trial exclusion criteria, people were not eligible if they had a vascular disease, pre-existing dementia or major physical disability, or the known presence of an illness that would compromise survival for the next five years. Also, the majority of the study population was Caucasian, and all were community-dwelling. Therefore, the results might not be generalizable to ethnically diverse populations of older adults, populations of older adults with significant medical comorbidities or institutionalized older adults.

Oral health status was self-reported, which might have led to recall and/or social desirability bias. Survey response inaccuracy due to recall bias might not have been profound given that the participants were asked to recall/report on whether or not they have any of their natural teeth (yes/no response) rather than to report the number of teeth left. In contrast, social desirability bias might have affected the response accuracy for the question on the way older adults would rate their oral health (excellent/very good/good/fair/poor responses), and therefore the observed association between self-rated oral health and all-cause mortality, considering that older adults tend to positively overestimate their oral health status.[30] More objectively measured oral health status would have produced more robust measures for exposures. The outcome of the study encompasses deaths from any cause, and some of these causes, such as falls, motor vehicle accidents, might not be directly related to self-reported oral health status and edentulism. Potentially more plausible outcomes would be cause-specific mortality with more direct links to oral health status, such as cardiovascular disease-related mortality. We acknowledge that diet is an important confounder, however, no dietary data were available at the study baseline. Similarly, we acknowledge residual confounding. Despite the limitations, this is among the first studies exploring the prospective association of reported edentulism, oral health and their interplay with all-cause mortality, and it uses a large cohort of community-dwelling older adults aged 70 years or over.

Implications of study results for clinical practice and health policy

We observed that even in apparently healthy independent-living individuals aged 70 years and over almost a quarter of the population reported being edentulous, and about 14% reported having fair or poor oral health. This observed proportion of older adults reporting fair or poor oral health might be an underestimate of the true prevalence of poor oral health, as older adults tend to positively overestimate their oral health-related quality of life.[38] Therefore, health professionals should routinely enquire about the oral health of older patients, and pay special attention to and take preventative actions with older adults describing their oral health-related quality of life in negative terms.

We used a single-item measure to summarise how older adults perceive their oral health. This single-item measure is commonly used in large-scale population surveys,[39–41] as it is a non-invasive, valid and time- and cost-effective tool for assessing self-perception of oral health status.[42] It can also be used by non-dental providers,[42] and it is suitable for assessing and summarising oral health status in low-resource environments.[43] In older adults in particular, this simple single-item assessment tool can be used as a quick, effective and inclusive tool to assess oral health status, as age-related changes in cognitive and communicative functioning might lead to older adults leaving incomplete or biased responses to more difficult survey questions.[44]

The results of our analyses also indicate that edentulism, and especially both edentulism and poor or fair oral health, was associated with a greater risk of all-cause mortality in older adults. Therefore, a greater emphasis should be given to preventative oral health care in all people, including older adults, to prevent edentulism and improve their overall oral health. Preferably, this is to be coupled with oral health education, while special consideration might need to be given to older adults with both edentulism and reported poor or fair oral health who should be encouraged to regularly visit a dentist and improve oral hygiene habits to help prevent the occurrence of more complex oral and general health problems.

Considering that oral health is an integral part of general health, it might be essential that oral health care programs be integrated into general health programs to help improve oral health in older adults.[35] A more preventative focus on oral health care and its better integration with primary health care through universal health insurance/coverage might be essential to address the large burden of oral diseases in this vulnerable population group.[45]

Individual-level interventions might not be sufficient to reduce the large oral disease burden in older adults. Therefore, a population-focused approach is required to help prevent oral diseases through fluoridation of water supply, improved access to publicly funded dental care and provision of oral health education programs to improve the knowledge, attitudes and oral health-related practices in older adults.

CONCLUSION

In the study of more than 12 000 otherwise healthy older males and females aged 70 years and over, we observed that edentulism (vs. no edentulism) was associated with a 43% higher risk of all-cause mortality; while even higher risk (69%) was observed if older adults reported both edentulism and poor or fair oral health, compared to reporting having some natural teeth and good, very good or excellent oral health. Better integration of oral health care with primary health care might help orient dental services towards a more preventative focus, while population-level oral health education programs might help improve oral health literacy and oral health-related practices among older adults. These might be essential to help maintain functional and healthy dentition in older adults and prevent exacerbation of existing health conditions that might lead to early death.

ACKNOWLEDGEMENT

The authors acknowledge the dedicated and skilled staff in Australia and the Unites States for the carry out of the trial. The authors also are most grateful to the ASPREE participants in Australia, who so willingly volunteered for ALSOP and the general practitioners and medical clinics who supported the participants in the ASPREE study. Professor John McNeil is an NHMRC Leadership fellow (IG1173690). Dr Freak-Poli is supported by a National Heart Foundation of Australia Postdoctoral Fellowship (101927). Open access publishing facilitated by Monash University, as part of the Wiley - Monash University agreement via the Council of Australian University Librarians.

AUTHOR CONTRIBUTIONS

S Khan: Conceptualization; investigation; methodology; formal analysis; data curation; writing – review and editing; visualization; writing – original draft. **Y Chen:** Conceptualization; investigation; writing – original draft; data curation; writing – review and editing. **L Crocombe:** Writing – review and editing. **E Ivey:** Writing – review and editing; methodology. **AJ Owen:** Methodology; writing – review and editing; project administration. **JJ McNeil:** Methodology; investigation; validation; funding acquisition; project administration; writing – review and editing. **RL Woods:** Methodology; validation; writing – review and editing. **R Wolfe:** Methodology; funding acquisition; validation; writing – review and editing. **R Freak-Poli:** Writing – review and editing; methodology. **C Britt:** Data curation; project administration; resources; writing – review and editing. **D Gasevic:** Conceptualization; methodology; investigation; writing – original draft; writing – review and editing; validation; project administration.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

TRIAL REGISTRATION

International Standard Randomized Controlled Trial Number Register (ISRCTN83772183) and clinicaltrials.gov (NCT01038583).

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Table S1. Comparison of baseline characteristics of participants included in the study and not missing data on variables of interest and those missing data

Table S2. Oral health status of 12 809 adults aged 70 years and over

Table S3. The association of edentulism and self-reported oral health with all-cause mortality in 12 809 older adults: the results of Cox-proportional hazards regression

Table S4. The association of edentulism and self-reported oral health with all-cause mortality in 12 809 older adults: the results of Cox-proportional hazards regression after excluding participants (n=68) who died within the first 2 years from the start of the study

Table S5. The association of self-reported oral health with all-cause mortality in 12 809 older adults: the results of Cox-proportional hazards regression

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